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EVALUATION OF REMOTE SENSING IN CONTROL OF PINK COTTON BOLLWORM

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16. Abstract

The main objective of this investigation is to evaluate the use of a satellite in monitoring the cotton production regulation program of the State of California as an aid in controlling pink bollworm infestation in the southern deserts of California. Color combined images of ERTS-1 multispectral images simulating color infrared are being used for crop identification. The status of each field (i.e., crop, no crop, wet, plowed, harvested) is mapped from the imagery and is then compared to ground surveys taken at the time of each ERTS-1 overflight. Correlation has been to date 100%. A computer analysis will be performed to compare field status with the crop calendar in order to identify crops. Correlation is expected to be 80 to 90%. Cotton fields, because of their state regulated season which is exactly coincident with no other crop, are expected to be easily identified.

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PREFACE

The purpose of this investigation is to determine whether or not cotton fields in the southern California deserts can be identified. Cotton is regulated by the State Department of Agriculture in an attempt to control the pink cotton bollworm. If cotton fields can be identified using satellite imagery, this would provide an efficient and economical method of mapping these fields.

Three agricultural areas are being studied: the Imperial, Coachella, and Palo Verde Valleys. A crop calendar comparison technique using all crops in the Imperial Valley is being conducted in cooperation with the Geography Department at the University of California at Riverside. The other two valleys will be studied by observing all bare fields during the winter months and noting which ones correspond to irrigation and plant development of the cotton season beginning in March.

Color combined images produced by the Diazochrome process are being interpreted for field condition and the results are then compared to field survey operations. To date the results compare exactly. Computer analyses to be performed over the next six months are expected to provide 80 - 90% accuracy in crop identification.

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I. INTRODUCTION

The main objective of this investigation is to evaluate the use of a satellite in monitoring the cotton production regulation program of the State of California as an aid in controlling pink bollworm infestation in the southern deserts. It should be stressed that this is only the initial and most obvious objective. If the proposed investigation is successful, the potential of such a satellite monitoring program for agriculture is unlimited.

The State regulation for controlling pink cotton bollworm is used in all three valleys to be studied in this investigation: the Coachella, Imperial, and Palo Verde Valleys. This regulation states that all acreage to be planted to cotton must adhere to the following rules. Cotton may not be planted in the Coachella and Palo Verde Valleys until February 28, and February 15 in the Imperial Valley. By December 15, all cotton fields must be picked, all remaining plant material must be thoroughly shredded and subsequently plowed underground. Those fields must then be left fallow until the following February unless another crop besides cotton is to be planted in those fields. The "plowdown" procedure is to insure that any pink bollworms in the larval stage will have no cotton plant material on which to feed.

The most immediate potential exists in the cooperative regulation of cotton production between California, Arizona, and Mexico. Substantial areas of cotton exist in the Arizona area bordering the southern California deserts and in the areas of Mexico bordering the southern California deserts. Both of these areas represent substantial sources of pink bollworm infection for California. Therefore, if the management system imposed upon cotton producers by the California Department of Agriculture is not successful, it will be imperative to determine whether the lack of success is due to the failure of growers in California to comply with the regulations or to the fact that insects are entering the diapause in readily available sources of plant material in Mexico and Arizona and then spreading into the southern California area. If the regulatory program proves successful, it would be our intention to expand the monitoring program in ERTS-B to include surveillance of cotton production and plowdown in Mexico and Arizona.

Another application of this research could be the extension of such a management system employing satellite monitoring to other crops in California and the rest of the United States. The use of chemical pesticides for the control of insects is coming under increasing criticism, and it is recognized by scientists the world over that other means of control must be utilized whenever possible. One means of control is that of pest management, i.e., the kind of improved management that we are attempting to develop in the cotton fields of the southern California deserts. There are many other instances of crop production in the United States, indeed the world, where insect control could be improved by removing a crop before an insect pest enters the diapause stage. Whenever such programs involve substantial acreage, the assurance that growers are cooperating in observing a regulatory schedule is imperative. The use of satellite sensing devices to provide such grower assurance could easily prove to be the simplest means of monitoring available.

Furthermore, the proposed investigation might also play a significant role in averting a far greater disaster than the current pink bollworm threat to cotton crops in southern California. Although the California desert areas produce 80,000 acres of cotton annually, the State of California in its entirety produces over 700,000 acreas of cotton, the bulk of which is concentrated in the San Joaquin Valley. It is a major effort of the Federal government, the California Department of Agriculture, and the University of California to insure that pink bollworm does not spread into this area of cotton production. If such a disaster should occur, then it would be necessary to adopt a management program in the San Joaquin Valley similar to the one in effect for the southern California desert. Thus, it would become necessary to monitor the defoliation, plowdown and replanting dates for 650,000 acreas of cotton rather than 80,000 acreas. Obviously, it would be almost impossible to carry out such a massive management program without the development of some remote sensing system.

Three agricultural areas are being studied: the Imperial, Coachella, and Palo Verde Valleys. A crop calendar comparison technique of all crops in the Imperial Valley is being conducted in cooperation with the Geography Department at the University of California at

Riverside. The other two valleys will be studied by observing all bare fields during the winter months. Cotton is requlated by the State Department of Agriculture and planting does not begin until February 28 in these two valleys. Thus by noting which bare fields become irrigated and subsequently develop a crop signature during the early part of the cotton season, the identification of cotton fields should prove highly feasible.

Color combined images simulating color infrared (CIR) are produced using the Diazochrome process and are then interpreted for field condition (i.e., crop, no crop, wet, bare, harvested). These results are then compared to field survey observations and, to date, have corresponded exactly. Computer analyses to be performed over the next six months are expected to provide 80 - 90% accuracy in crop identification.

II. STATUS OF WORK PROGRESS

In order to detect cotton fields from ERTS-1 images, it was determined that the simplest method would be to compare the crop calendar of cotton (i.e., planting, growing, harvesting) to those of other crops. A base map of the Imperial Valley was readily available from the Geography Department at the University of California at Riverside (1). The field boundaries were updated using the U-2 imagery requested for this study and each field was assigned a number. Thus, with each pass of ERTS-1 data, each field will be assigned one or more of the following descriptor codes: (1) crop, (2) no crop, (3) wet, (4) bare, and (5) harvested. This information, in addition to the calendar for each crop, and field size, will be analyzed by computer to determine statistically what crop is most likely to be found in a given field at a given time. Since the cotton season is regulated by state law and is exactly coincident with no other crop, detection of cotton fields greater than twenty acres in size should not be difficult.

During each ERTS-1 pass, a field survey is conducted to obtain approximately a 10% sample of the Imperial Valley. After each ERTS-1 image has been interpreted, i.e., each field having been coded, the field survey is then matched to determine the accuracy of the interpretation. The comparisons which cover the first three passes have been 100% accurate. The computer analysis, which has not yet been conducted, will also be compared to the field survey. It is estimated that 80 - 90% accuracy will be obtained.

The Coachella and Palo Verde Valleys are also being examined in this study. A different method of interpretation will be used to detect cotton fields in these valleys. The locations of all cotton fields in each valley has been acquired from the respective Agricultural Commissioners' offices. During the months of December, January, and February, all cotton fields must be completely bare. On February 28 irrigation will begin in cotton fields. Cotton develops rapidly and should be identifiable on film about one to two months after irrigation begins. Thus by noting irrigation of bare fields at the end of February and the development of a crop signature by mid-April, the mapping of 80 to 90% of all cotton fields in each of the valleys should be possible.

III. SIGNIFICANT RESULTS

It was determined that color images were vital for the success of this project. Since color images were not available from NASA-Goddard, the Geography Department at the University of California at Riverside agreed to allow us use of their I^2S (International Imaging Systems) color combiner when it becomes available in Janurary. However, this would cause some delay and another method was sought. A simple rear view projection system would not allow the quality necessary for this project. Another method is using the Diazochrome process. In this process, each of the multispectial (MSS) bands is exposed to an appropriately colored Diazochrome film and then subsequently developed by ammonia vapors. Initially, Diazochrome colors have been matched to the MSS bands according to the dye-layers of color infrared (CIR). Each band image is now a different color; they are superimposed using the registration marks, and taped together. The result is a color combined image comparable in quality and registration to the original images and much like a conventional CIR image.

The color combined image is then projected onto the base map which is on opaque acetate and interpretation proceeds from there. Since the combined image simulates CIR, interpretation for the agricultural descriptor codes is as follows: red - crop, white - bare, yellow - harvested, dark lavendar - wet, and light lavendar - plowed.

Because the Diazochrome process allows cheap and efficient production of simulated CIR images, the interpretation of data has been significantly enhanced. The image data corresponds exactly with field survey operations. Because of the regulated cotton season, it is expected that further investigation in using either crop calendar comparisons or bare field observation will prove highly reliable in detecting 80 - 90% of all cotton fields in the Coachella, Imperial, and Palo Verde Valleys.

IV. PROGRAM FOR NEXT REPORTING INTERVAL

The two basic functions that will be carried out for the next reporting interval are (1) interpretation and analysis of information presently available and (2) experimentation with the color combiner to see if enhancement of reliability can be achieved.

Interpretation and analysis of present information will consist of coding maps from data taken from each ERTS-1 pass. The data will then be computer analyzed and CALFORM maps will be produced for each ERTS-1 pass showing what crop is most likely to be present in any given field at a given time. As more data is acquired, the "time" maps should become increasingly more accurate. In addition, field surveys will continue in order to check the accuracy of this method of crop analysis.

We cannot say at this time what exact results will be achieved by the use of the color combiner. They should be comparable to results obtained using the Diazochrome process since the 70 mm positive transparencies received to date are of excellent quality. Also the ease of color combining may produce combinations not available otherwise and better results may be possible.

V. CONCLUSIONS

The ERTS-1 data is of very good quality and at this point it seems that detection of cotton fields will be easily accomplished. The Diazochrome process allows for quick and cheap production of good color combined images. The data interpreted from these images compares exactly with field survey observations. It is expected that computer analysis of the ERTS-1 data will provide highly reliable results regarding the location of cotton fields.

VI. APPENDIX

A change in the standing order for this investiation was requested on October 27, 1972. The cloud cover requirement was changed from 30 to 50%, continuous ERTS-1 coverage was requested for the dates of July 1, 1972 to May 30, 1973, and 70 mm positive transparencies were ordered in addition to the 9" X 9" format.

Data requests were made on October 27, 1972 for 70 mm positive transparencies of all ERTS-1 coverage prior to November 5, 1972.

REFERENCES

1. Johnson, Claude W., et al., A System of Regional Agricultural Land Use Mapping Tested Against Small Scale Apollo 9 Color Infrared Photography of the Imperial Valley (California), U.S.D.I. Contract No. 14-08-0001-10674, Technical Report V, November, 1969.

ERTS IMAGE DESCRIPTOR FORM

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DATE December 13, 1972

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ORGANIZATION Plant Science Dept., Univ. of Calif. at Riverside

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ID

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	Agric.	Irrig.	Desert	
1015-17440-M; 1051-17441-M; 1069-17441-M	X	X	X	Palo Verde Valley River, exotic Canals Highway Alluvial Fans Sediment Bedrock Faults Dunes

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS* Agric.	Irrig.	Desert	DESCRIPTORS
1034-17500-M; 1052-17495-M: 1070-17495-M	X	X	X	Imperial and Coachella Valleys Graben Lake Rivers Canals Highway Alluvial Fans Sediment Bedrock Faults

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	Agric.	Irrig.	Desert	
1015-17442-M	X	X	X	Mexicali Valley River, exotic Meanders Delta Gulf Dunes Canal Alluvial Fans Sediment Bedrock

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	Agric.	Irrig.	Desert	
1053-17551-M	X	X	X	Riverside, San Bernardino
				Urban area
				River
				Mountains
				Fault
				Highways
				Lakes
				Alluvial Fans
				Sediment
				Bedrock
				Faults

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	Agric.	Irrig.	Desert	
1051-17434-M	X	X	X	Bard Valley, Havasu Lake Canals Highway River, exotic Lake Alluvial Fans Sediment Bedrock Faults

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	Agric.	Irrig.	Desert	
1034-17493-M; 1053-17493-M	X	X	X	Mojave Desert Alluvial Fans Playas Sediment Bedrock Faults

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